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# Working memory and cued recall

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**Working Memory and Cued Recall**

An Honors Thesis submitted in partial fulfillment of the requirements for Honors in the  
Department of Psychology.

By  
Maximilian Fey  
Under the mentorship of Dr. Karen Naufel

**ABSTRACT**

Previous research has found that individuals with high working memory have greater recall capabilities than those with low working memory (Unsworth, Spiller, & Brewers, 2012). Research did not test the extent to which cues affect one's recall ability in relation to working memory. The present study will examine this issue. Participants completed a working memory measure. Then, they were provided with cued recall tasks whereby they recalled Facebook friends. The cues varied to be no cues, ambiguous cues high in imageability, and cues directly related to Facebook. The results showed that there was no difference between individual's ability to recall their Facebook friends and their working memory scores. However, those in the ambiguous cue condition were able to recall significantly fewer Facebook friends than those in the Facebook cue or no cue condition. Thus, this research shows that ambiguous cues can interfere with recall. However, further research is needed to see the extent that working memory moderates this effect.

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## **Introduction**

Memory is an integral part of every person's life, but the processes that make up the framework of memory recall are still in question. Memory cues can help a person remember (Tulving & Thomson, 1973). For example, a person may wander up and down the aisles at a grocery store to jog a memory of what was on a grocery list that was accidentally left at home. However, memory cues may also be a hindrance (Migueles & Garcia-Bajos, 2015). For example, a person may be trying to remember their grocery list while their phone is buzzing with updates about a football game. The constant updates would cue the recall of memories of the sports team as opposed to the memory for the items on the grocery list. Both situations can happen. This research tested the extent that individual characteristics predict how people to recall specific memories in the presence of relevant vs. irrelevant cues.

## **Autobiographical Memory**

Autobiographical memory refers to an individual's personal and vivid memories, like buying your first car or the first time you saw the ocean. Baddeley (2001) breaks down long-term memory into implicit and explicit memories. Baddeley defines implicit memory as a collection of skills and pre-dispositions that are the product of our experiences. Some examples of things that fall under implicit memory are skills, habits, priming, simply classical conditioning, and non-associative learning. Baddeley defines explicit memory as the conscious recollection of events and facts, such as remembering items on a grocery list. He breaks down explicit memory into two categories: semantic and episodic. Semantic memory refers to knowledge that we have about how the world works. For example, a semantic memory would be the knowledge of how

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many inches are in a mile or what color a ripe banana is. Episodic memory on the other hand is the ability to recall specific personal events. For example, remembering your child's first baseball game would be an episodic memory.

Baddeley (2001) has broken down long-term memory into multiple categories, with episodic memory being the most relevant to the concept of autobiographical memory.

*Autobiographical memories* are simply episodic memories which are specifically related to the individual themselves. For example, an autobiographical memory would be one's vivid memory of the first time that they ate lemon ice cream.

The retrieval of autobiographical memory can be both intended (effortful) or unintended (automatic). Harris, O'Connor, and Sutton (2015) posited that autobiographical memories can be categorized as being either directly or generatively retrieved. Direct retrieval refers to remembering without an experience of effortful searching. On the other hand, generative retrieval refers to remembering with an experience of deliberate or effortful search such as through the use of cues. In their study participants were provided with cue words and then asked whether or not a memory just "popped" into their mind or whether they had to generate one. They then rated those memories on their visuo-spatial perspective, or how vivid the memory was. Harris et al. (2015) found that directly recalled autobiographical memories were recalled at a faster rate when compared to generative memories. The researchers concluded that cue generation and memory construction may overlap, even though the two concepts are conceptually distinct.

Autobiographical memories can be retrieved in a variety of ways, and the memories are not always voluntary retrieved. Further research by Rasmussen, Ramsgaard, and Bernsten (2015) discussed the difference between voluntary and involuntary autobiographical memories, which

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are similar to Harris et al.'s directly or generatively retrieved memories. Involuntary memories come to mind without effortful searching. Voluntary autobiographical memories are the product of deliberate strategic retrieval processes. Participants took an online questionnaire and were provided with a mechanism to keep track of all of the memories they retrieved. The online questionnaire cued certain memories and asked the participants to record whether or not they voluntarily or involuntarily retrieved those memories. The recall rate of involuntary memories was dependent on the recall activity, whereas voluntary memories were recalled at the same rate across all conditions. Voluntary memories were shown to have more salience in regards to the intention of the recall task. In other words, voluntary memories are more useful to whatever task an individual is doing because those memories were recalled specifically to aid in that task. As the authors state, this research suggests that voluntary memories are more consistently recalled, and they are often more salient to the activity at hand. Although voluntary memories are more consistently recalled, research should investigate the involuntary memories being recalled. There is a possibility that involuntary memories are more easily recalled during certain situations because of the activation of certain primers or cues that lead to the target memories being recalled, but this remains to be tested.

Autobiographical memories are at times over-ridden or forgotten. Migueles and Garcia-Bajos (2015) conducted research on what they call retrieval induced forgetting. Retrieval induced forgetting (RIF) is a phenomenon that refers to the idea that remembering one target memory inhibits and causes one to forget other similarly related memories that share many of the same cues and characteristics as the target memory. The study in question tested whether or not RIF has an effect on future autobiographical experiences. The researchers tested this by having participants remember past experiences or "remembering" future experiences with which the

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researchers had provided them. The findings showed that in both the past and future autobiographical memory conditions RIF was observed. The past autobiographical condition RIF was found to have less of an effect if the material was provided in a chronological order. Chronological order had no effect on the future condition, in other words, no matter how the information was presented RIF was observed. RIF forgetting is therefore extremely important to autobiographical memory retrieval because it shows that cues are an integral component of the retrieval process. A greater understanding of how these cues are generated and why they are associated with the target memories is an area of further research.

Retrieval induced forgetting suggests that memories are related, through related cues and temporal placement. Memory chains are conceptual or temporal links that draw memories together, these chains cause an individual to recall a “chain” of memories because they are in some way related or chained together. Mace (2014) distinguishes between temporal and conceptual chains. Temporal chaining refers to the order or sequence that events occurred, for example remembering the limo ride to a high school prom and then subsequently remembering the prom itself, one event occurred before the other making them temporally linked. Conceptual chaining refers to the idea that one remembers memories that share similar concepts or characteristics. The findings of the research are that temporal links tend to erode away whereas conceptual links maintain their relevance for a longer period of time. On the topic of what relates memories Begg and Nicholson (1994) distinguished between semantic and episodic relations in autobiographical memory. Semantic relations are previously associated concepts in one’s life (i.e. beer and alcohol) whereas episodic relations are the joint occurrence of previously unrelated concepts (i.e. chicken and sky scraper). The associations drawn between memories seems

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to suggest that if one were to fully understand the factors that lead to the creation of these associations one could improve recall ability through strategic searching.

The research explains the relations that make-up episodic memories. Episodic memories are specific and recalled in a variety of ways. Cues work by activating or “jogging” one’s memory in such a way that allows them to remember a target memory. However, the role of cues in the recall of episodic memories is not concretely established, and as such more research should be conducted. Episodic memories are recalled in a variety of ways and multiple factors play a part in determining how it is that an episodic memory is retrieved in contrast to the competing memories. More research can be done on the general process of how it is that episodic biographical memories are retrieved.

## **Working Memory**

Remembering autobiographical memories is dependent on the cues used to search for target memories, an individual must therefore attend to these cues which may be related to working memory. Baddeley (1992) defines working memory as the system that allows one to briefly store, utilize, and change information. This information can then be used for a variety of tasks such as learning and language comprehension. Baddeley further breaks down working memory into three separate components: the central executive, the visuospatial sketch pad, and the phonological loop. The central executive allows one to attend to and switch between information in the working memory. The visuospatial sketch serves the function of allowing one to manipulate visual imagery. The phonological loop serves the function of storing and rehearsing speech based information for the acquisition of native and second language

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vocabulary. The central executive is the most relevant component of the working memory in relation to attending to cues. The central executive allows one to switch between and pay attention to a variety of cues.

Cues are generated and used to recall memories. Tulving and Thomson (1973) did research on the relationship between cues and memory retrieval. What they found was that retrieval cues are dependent on the specific encoding operations performed. A cue's relationship to a retrievable memory or concept is primarily established during the encoding process. Forward associations (i.e. cue presented first then asked about target word) are stronger than backward associations (i.e. target word presented first then asked for cue word). This research therefore suggests that the encoding process plays an integral role in the formation a link between a cue and a target memory.

Having established the relationship between cue generation and retrieval, one must also look at the different sorts of cues that can be used in memory retrieval. Williams, Healy, and Ellis (1999) conducted research on imagery and its effects on autobiographical memory retrieval. Participants were presented with varying cue words and then asked what specific memory was the first to pop into their head, the speed with which they responded and the vividness of the memories was rated. Their research found that the imageability of cues mediated the greatest specificity in the recall of specific memories. The research further tested which modality of imagery (visual, olfactory, tactile, auditory, and motor) had the greatest effect on autobiographical retrieval. Visual imagery was found to have the greatest success and specificity when recalling target autobiographical memories. Williams et al. (1999) suggest that visual imagery (imageability) represents the most effective way of summarizing information. Tse and Altarriba (2007) also conducted research on word imageability. They found the word



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imageability effect, such that high imageability cues were significantly more effective for the recall of specific memories in serial recall tasks than were low imageability cues. All of this research points to the imageability of cues being the most salient for recall, because of this one would assume that the generation of cues which are high in imageability would lead to faster and more accurate recall.

Cues obviously have an effect on memory recall, but to the extent to which cues effect one another is still somewhat undiscovered. Lohnas and Kahana (2014) conducted research in regards to the compound cuing effect. The compound cuing effect states that recalling a list of items is a dependent process whereby recalling the first items cues one to remember the second item, which then cues the recall of the third item and so on. Their research supported this compound cuing effect; such that, the first set of cues has an effect on the second and third sets of cues. When tested in terms of recall accuracy the first set has a greater effect on the second set of cues than it does on the third. To add on to this, the second set of cues has a greater effect on the recall of the third set than it does on the first set. As the authors point out, their research supports the compound cuing effect and it also found that the compound cuing effect is effective in the forward direction but not necessarily in the backward direction. The compound cuing effect therefore raises concerns when presenting an individual with a multitude of cues and how they may effect one another.

As these studies show cued recall is dependent on the cue itself, when one attends to those cues working memory is utilized. Souza, Rerko, and Oberauer (2014) looked into working memory and its relation to memory recall. The researchers were testing retro-cues, which they define as a cue presented after the encoding process that informs the participant on what information they will need to remember. Souza et al.'s (2014) procedure consisted of participants

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taking a cued recall task where they were presented with series of colors and asked to remember what colors had flashed. The participants were provided with some retro-cues on what they should have paid attention to, namely which colors. What they found was that retro-cues allow one to unload the working memory, therefore increasing the rate of recall. What the researchers found was that participants were able to attend to the useful information in their working memory while disregarding non-useful information, freeing up working memory capacity and increasing recall.

Working memory may be related to cued recall such that it allows one to attend to specific cues while ignoring others. Unsworth, Spillers, and Brewer (2012) posited a direct relationship between working memory and autobiographical memory retrieval. They suggested that working memory generates the cues necessary with which to search through one's autobiographical memory. Unsworth et al. (2012) suggested that individuals who have higher working memory would be able to generate more relevant cues with which to search their autobiographical memory when compared to individual's low in working memory. The researchers had participants take a working memory measure before a cued recall task where they were asked to recall as many Facebook friends as possible in 8-minutes, after this task they were asked to categorize their friends into a variety of groups such as college (dorm, class, social group, etc.), high school (class, social group, team), and other (family members, friends, work, etc.). The researchers analyzed the responses and the categories that those responses fell into, all in relation to the working memory capacity of the individual. They take the position that working memory is the driving force behind the generation and attention to cues that allow for one to strategically search through their autobiographical memories. The researchers did not test how

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different cues may effect one's ability to recall memories, and research needs to be conducted to vary the nature of the cues used.

In sum, the research on working memory and cued recall points to the greater effectiveness of cues which are high in imageability when compared to cues which are low in imageability. The research also establishes the importance of the encoding process on the strength of a cue. Unsworth et al. (2012) suggested that working memory plays a role in one's ability to generate cues with which to search autobiographical memory. The results of their research showed that individuals high in working memory capacity were able to recall more friends at a faster rate, and they were able to generate the strategic categories more easily when compared to individuals who scored low in working memory capacity.

### **Statement of Problem**

Research has shown that cued-recall is dependent on the type of cue presented and how it is encoded; furthermore, research suggests that working memory capacity is related to one's ability on a recall task (Unsworth et al., 2012). Research has not tested the effects of working memory capacity on cued-recall tasks that vary in the imageability and relevance of the cues. The proposed research will fill this gap by testing the relation between working memory capacity and the ability to recall, specifically in regards to the type of cue. This research partially replicates Unsworth et al.'s (2012) research. Participants were provided with either no cues, Facebook cues which are related to the target memories, or high imageability cues which are unrelated to the target memories; they were then be asked to recall the target memories. Based on Unsworth et al.'s (2012) research that suggests that working memory capacity is positively related with one's ability to recall autobiographical memories, it is predicted that working memory capacity will predict one's ability to recall items regardless of the cues presented; such

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that individuals who score high in the working memory measure will recall significantly more items in the recall tasks than will those individuals who scored low in the working memory measure. The specific hypotheses are as follows :

- H1: Individuals who score in the top 50% of the working memory measure will recall significantly more Facebook friends when compared to the lower 50%.
- H2: Cue type will predicate individual's ability to recall, such that the high imageability Facebook condition will show no difference between high and low working memory individuals and their ability to recall; whereas both the ambiguous and no cue conditions will show the higher working memory individuals recalling more memories than the low working memory individuals.

## Method

### Participants

The participants were Georgia Southern University students. This study consisted of 62 total participants, 40 female and 22 male. Twenty of the participants were first year students, 29 sophomores, 7 juniors, and 6 seniors. Students received credit towards their Introductory Psychology course for taking part in the study.

### Design and Materials

The study was a 2 (working memory span: high vs. low) X 3 (cue type: ambiguous vs. Facebook vs. no cue) mixed model design.

Working Memory. This study utilized the working memory span task, Ospan provided by Unsworth, et. al (2012). The span task consisted of math problems ( $10 + 2/3 = ?$ ) which were

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interspaced with letters that the participants were asked to remember. There was a total of sixty-two trials. The results of the Ospan were analyzed at a median split, such that those who scored in the top 50% of the Ospan were compared to those who scored in the bottom 50% of the Ospan. A median split was conducted because in Unsworth et al.'s (2012) research only the 25% and lowest 25% were analyzed to insure that the participants in question could actually be considered high or low in working memory capacity; however, due to limitations in the amount of participants that could be run in this study a median split was decided upon to include all of the participants who took part.

Cue Type. The participants were randomly assigned to one of three conditions: no-cue, Facebook-specific, or ambiguous-high imageability. The no-cue condition provided the participants with no cues, and asked the participants to recall as many friends as possible. The Facebook-specific condition provided the participants with cues taken directly from Facebook's categorization of friends (Work, University, High School, Current City, Family). The ambiguous high imageability condition provided the participants with cues which were high in imageability but irrelevant to the recall task itself (Apple, Crown, Sock, Pen, Tower)

To ensure that these cues were perceived as high imageability and were or were not related to Facebook, a pilot study was run to analyze the extent to which individuals perceived certain words as being high in imageability or related to Facebook. Thirty-four participants completed a survey consisting of 32 questions which asked participants to rate how much they associated certain words with Facebook and how imageable the participants rated the words as being on a 1-7 Likert-scale (1 = not at all; 7 = very much). Participants received a candy bar for their efforts in completing this study. A repeated measures ANOVA was used to analyze these data. A main effect of imageability was found:  $F(2, 32) = 27.12, p < .05$  such that the high

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imageability ambiguous cue words ( $M = 6.39$ ,  $SD = 1.02$ ) and Facebook cue words ( $M = 6.30$ ,  $SD = .99$ ) were higher in imageability than the low imageability cue words ( $M = 4.81$ ,  $SD = 1.42$ ). A second repeated measure ANOVA was conducted and found an effect for Facebook relatedness:  $F(2,32) = 75.75$ ,  $p < .05$  such that the Facebook cue words ( $M = 4.33$ ,  $SD = 1.20$ ) were significantly associated with Facebook when compared to the high imageability ambiguous cue words ( $M = 1.74$ ,  $SD = .71$ ) and the low imageability ( $M = 2.50$ ,  $SD = .97$ )

## Procedure

Participants read and signed the informed consent. Participants sat down at one of four computers, and these computers had Unsworth et al.'s automated Ospan task pulled up on them. The participants followed all of the on screen instructions. After having completed the Ospan task the participants flagged down the researcher so that their Ospan tasks could be closed out and the computer would output their results in a separate file folder. After each participant had completed the Ospan task the participants were then randomly assigned to one of the three recall conditions (no-cue, Facebook-cue, ambiguous-high imageability). Participants read the instructions and were given six minutes to recall and write down as many Facebook friends as possible. After the allotted six minutes was up all of the participants stopped writing. The participants then signed into their respective Facebook pages and went directly to their friends list, the researcher validated each participant's responses by manually searching for each friend that the participants listed in the recall task. The researcher took note of how many friends the participant wrote down, how many of those friends were present on the participant's friends list, and how many friends the participant has total on their friends list. Lastly, the participants filled out a demographics sheet which included their sex, year in school, and how often they used Facebook.

## Results

Total number of Facebook friends was calculated by dividing the total number of friends recalled by the total number of possible friends. Additionally, false positives, or other friends, were counted as friends that were recalled that were not actually Facebook friends.

The predicted results of this research fell in line with Unsworth et al.'s (2012) research that working memory capacity had an effect on recall ability, such that individuals high in working memory are able to recall significantly more Facebook friends across all conditions. A 2 (working memory) x 3(cue type) MANOVA was conducted with the percentage of total friends recalled and the total amount of non-Facebook friends recalled as the dependent variables. The main effect for Working Memory was non-significant of  $F(2, 55) = .17, p > .05, \eta^2p = .001$ . The interaction between the two variables was non-significant,  $F(4,112) = .171, p > .05, \eta^2p = .006$ . However, cue type was significant,  $F(2,112) = 2.54, p < .05, \eta^2p = .087$ . A simple ANOVA was conducted controlling Type I error with Tukey's HSD, cue type had a significant effect on other Facebook friends recalled such that the ambiguous cue ( $M = 5.64, SE = .52$ ) condition recalled more than the Facebook cue ( $M = 2.90, SE = .53$ ) and the no cue ( $M = 2.43, SE = .48$ ) conditions.

## Discussion

The proposed hypothesis suggested that those individuals with higher working memory should be able to recall more friends on Facebook than those with low working memory because those individuals with high working memory are able to generate the necessary cues with which to search through their autobiographical memory. However, in regards to the cues, when

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provided with the Facebook cues those individuals with low working memory should be able to recall just as many friends from Facebook compared to individuals with high working memory.

These results did not occur: There was no difference in Facebook friends recalled across all conditions. A variety of factors could have contributed to the observed results. A median split was utilized in this research to include all of the participants; the study consisted of only 62 participants. In Unsworth et al.'s (2012) research they analyzed only the top 25% and the lowest 25% in regards to working memory to insure that those individuals could actually be considered "high" and "low". The relatively low sample size of this study forced the use of a median split so that a sufficient amount of individuals could be classified as high and low in regards to working memory. According to McClelland et al. (2015) median splits have a variety of issues, including the introduction of random error and a reduction in power. The introduction of error into the results could have led to the observed results; furthermore, the reduction of power (which is compounded by the low sample size) severely reduces any conclusions that could even be drawn by this research. More participants were needed to sufficient power, as Cohen (1992) suggests a 3 group ANOVA with  $p = .05$  should consist of 52 participants per group for a total of 156 participants. The current research study consisted of 62 participants across all six groups ( $N = 10.33$ ), which is vastly less than the suggested 52 per group for sufficient power.

In addition, the predicted results also could not have occurred as a product of the participants not taking the working memory measure as seriously as they should have. An observed effect of the participants was a general impatience and annoyance in regards to the working memory measure. The participants seemed to audibly sigh, look around the room, and look annoyed as they progressed through the OSpan task. This could have caused the results of the working memory measure to be inaccurate due to disinterest on the part of the participants.



Contrary to observed annoyance and indifference of the participants, the working memory distribution was negatively skewed, such that the majority of participants scored within the upper half of the working memory measure. This could suggest a ceiling effect or an inability to properly measure or distinguish between high working memory individuals. There is a possibility that the upper reaches of the working memory measure were not sensitive enough to distinguish between differences in working memory and therefore the results were skewed in such a way that high working memory cannot be properly analyzed. Even though some of the participants appeared to not take that measure seriously a negative skew was still observed, this may support the idea that the measure was not sensitive enough to distinguish between the working memory capacity of the participants. The population that was analyzed consisted of entirely college students and as such all of those individuals may already be above average in working memory; therefore, the working memory measure may not have been sensitive enough to the differences between individuals working memory capacity.

Future research could look to first and foremost increase the sample size so as to have proper power. A more accurate working memory measure could also be used to further distinguish between high and low working memory capacity. Another suggestion would use some other measure of autobiographical memory retrieval than Facebook friends. Participants can vary greatly in their usage of Facebook. For instance, in this study, participants reported an estimate of how often they checked Facebook each day ( $M = 4.20$ ,  $SD = 13.1$ ), and as such some may be more familiar with the target memories than others. In future research a more generalized and shared target for the recall task could possibly benefit the results.

The proposed hypothesis did not occur, but ambiguous cues did cause participants to recall more non-Facebook friends or friends who were not the target of the recall task. This

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seems to suggest that cues do have an effect on memory recall such that they can cause individuals have false-positive memories in relation to the recall task. McKoon and Ratcliff (1992) discuss that compound cue's work in such a way that the priming cue is associated directly with the target memory and furthermore the semantic relationships between the words are activated through compound cuing. This research on compound cuing could be used to explain the observed effects of ambiguous cues such that the ambiguous cues cause the activation of semantic networks which are completely unrelated to the target memories, which then leads to false recall. Further research on cued recall by Nelson et al. (2013) suggests that the activation of a semantic network by a cue causes the individual to search the specific "neighborhood" or the words and memories that are related to the cue. This research seems to suggest that the priming effect of the ambiguous cues could cause participants search through unrelated semantic networks which would cause an increase in false-positive recall. The results of this study are therefore interesting in that they support the current literature in regards to the significant priming affects that cues can have. Individuals recalled significantly more non-Facebook friends in the ambiguous condition can this is more than likely the product of unrelated semantic networks being activated by the completely un-related cues.

Further research could look to further distinguish the ambiguous cues into different categories to test whether or not these cues actually cause the recall of unrelated semantic networks. Research into cued recall could also present participants with a mixture of related and un-related cues to see what effect that could have, participants could ignore the ambiguous cues and only attend to the related ones or the ambiguous cues could still have an effect on recall ability.

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Overall, the research did not affirm the proposed hypothesis. This could be caused by a lack in power or by the inherent problems with a median split. The results did show that the ambiguous cue condition resulted in participants recalling more non-Facebook friends which supports the existing literature on cued recall and compound cuing. Even though the proposed hypothesis was not supported further research should be conducted to test a possible connection between working memory capacity and the ability to generate and attend to cues.

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